[0254] Sources of Avs Measurement Error-External Noise

[0255] In some embodiments, external noise sources may be filtered out.

[0256] Sources of Avs Measurement Error-Mechanical Shock

[0257] Mechanical shock to the pump housing during an AVS measurement will affect the microphone measurements and may result in an error in the frequency response data. This error, however, is detectable using the out-of-band variance check in the demodulation routine by the processor **21** of FIG. **2**. If such an error is detected, the data point can be repeated (e.g., another sample is taken) resulting in little or no effect on the resulting AVS measurement.

[0258] Sources of Avs Measurement Error-Air in the AVS Chamber

[0259] A mechanism for an air bubble to affect the AVS measurement is through a secondary resonance. This secondary resonance will make the system 4^{th} order and, depending on the frequency and magnitude of the secondary resonance, can cause some error if the estimation is using a 2^{nd} order model.

[0260] Sources of Avs Measurement Error-Electrical Component Failure

[0261] In general, failure an electrical component will result in no signal or in increased harmonic distortion. In either case the fault would be detected by AVS integrity checks and the measurement invalidated.

[0262] The one exception that has been identified is a failure of the oscillator used to control the DAC and ADC. If this oscillator were to drift out of tolerance it would introduce a measurement error that would not be detected by the low-level integrity check (it would be detected in an extreme case by the volume integrity checks described above). To guard against these failures, in some embodiments, the oscillator is checked against an independent clock whenever an AVS measurement is initiated.

What is claimed is:

1. A pump, comprising:

an acoustic housing;

an additional acoustic housing

a reservoir configured to deliver a liquid, wherein the reservoir is disposed within the acoustic housing;

a port coupled to the reservoir and configured to discharge the liquid;

a plunger having a piston coupled to a shaft, wherein the plunger is disposed within the acoustic housing, wherein the piston is disposed within the reservoir in sliding engagement with an inner surface of the reservoir, wherein the piston defines a liquid side of the reservoir and a non-liquid side of the reservoir whereby movement of the plunger towards the liquid side of the reservoir discharges liquid through the port;

an additional reservoir configured to deliver an additional liquid, wherein the additional reservoir is disposed within the additional acoustic housing;

an additional port coupled to the additional reservoir and configured to discharge the additional liquid;

an additional plunger having an additional piston coupled to the additional shaft, wherein the additional plunger is disposed within the additional acoustic housing, wherein the additional piston is disposed within the additional reservoir in sliding engagement with an inner surface of the additional reservoir, wherein the additional piston defines a liquid side of the additional reservoir and a non-liquid side of the additional reservoir whereby movement of the additional plunger towards the liquid side of the additional reservoir discharges liquid through the additional port; and

a reference-volume assembly coupled to the acoustic housing through an acoustic port, wherein the reference-volume assembly is coupled to the additional acoustic housing through an additional acoustic port, wherein the reference-volume assembly comprises:

a reference-volume chamber in acoustic communication with the acoustic housing via the acoustic port, wherein the reference-volume chamber is in acoustic communication with the additional acoustic housing via the additional acoustic port;

a speaker disposed within the reference-volume chamber; and

a reference microphone disposed within the reference-volume chamber.

2. The pump according to claim **1**, further comprising an actuator coupled to the shaft to actuate the plunger.

3. The pump according to claim **2**, wherein the actuator is disposed within the acoustic housing.

4. The pump according to claim **1**, further comprising an additional actuator coupled to the additional shaft to actuate the additional plunger.

5. The pump according to claim **2**, wherein the actuator is disposed within the acoustic housing and the additional actuator is disposed within the additional acoustic housing.

6. The pump according to claim **1**, further comprising a manifold, the manifold comprising:

a first connector port coupled to the port;

a second connector port coupled to the additional port;

a discharge port; and

a liquid path fluidly connecting together the first and second connector ports to the discharge port.

7. The pump according to claim **6**, wherein the manifold is attachable to the first and second connector ports.

8. The pump according to claim **1**, wherein the piston comprises a seal disposed along a periphery of the piston.

9. The pump according to claim **1**, wherein the reservoir is cylindrically shaped thereby defining a circular cross section; and wherein the piston engages the inner surface of the reservoir along the circular cross section.

10. The pump according to claim **1**, wherein the reservoir is cuboid shaped thereby defining a rectangular cross section; and wherein the piston engages the inner surface of the reservoir along the rectangular cross section.

11. The pump according to claim **1**, further comprising a vent in fluid communication with the non-liquid side of the reservoir.

12. The pump according to claim **11**, wherein the vent is further configured to acoustically seal the non-liquid side of the reservoir from outside the reservoir.

13. The pump according to claim **1**, further comprising a one-way valve in fluid communication with the non-liquid side of the reservoir, wherein the one-way valve is configured to allow gas to enter into the non-liquid side of the reservoir from outside the reservoir.